THE ESTIMATION OF CONSTRUCTION JOBS

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THE ESTIMATION OF CONSTRUCTION JOBS

The questions most frequently asked of the construction estimator are how long it will take to build an installation, how much it will cost, and how soon he can answer these questions. The answering requires some kind of estimative process, which may vary from what seems a mere intuitive guess to a time-consuming analysis of extensive data by complex methods. Among the more important determinants of the process are the qualifications of the estimator, the availability of data, and the methodology employed.

The process as carried out for intelligence purposes is generally similar to that used by the construction industry itself. In the construction industry, however, estimates are made primarily to determine the best and most economical way to do the job, whereas intelligence wants to know the actual cost and the time required, given the materials and construction methods in fact used. This distinct approach sets the intelligence process apart from that common in pre-bid estimating for construction projects. Moreover, the paucity of data available to intelligence usually precludes detailed analysis and requires a large measure of extrapolation and approximation.

Especially in intelligence, therefore, the validity of an estimate depends in large part on the estimator's practical experience and maturity of judgment. He should be thoroughly familiar with all aspects of the work involved in the project at hand. There is no substitute for the know-how imparted by long and varied experience on field construction jobs, and the estimate prepared in the office must reflect this field experience. Ideally, in view of the considerable differences in construction technology in different countries, the intelligence

estimator should have obtained some of his field experience in the country in question. Since this is seldom possible, he must consciously adapt his experience to the building methods prevailing there and minimize the use of direct analogy with U.S. practice.

On construction projects in the USSR the best single source of basic working data is found in the Soviet Norm Books for Construction, which list labor and equipment requirements and the cost for such units of work as excavating a cubic meter of earth or rock, placing a cubic meter of concrete, and erecting a ton of steel. Composite cost and time requirements for constructing various types of residential industrial and public buildings per square meter of floor area are also given. Architectural journals furnish a great deal of helpful information on building construction; similarly transportation publications in the field of railroad, highway, and waterway construction and maintenance. Soviet handbooks give specifications for construction machinery and equipment and for building materials, and construction journals and newspapers place these specifications in practical context for the experienced construction estimator by discussing difficulties in the actual performance of equipment and materials on the job. Newspaper accounts of operations on current projects shed light on specific problems and how they are overcome.

Much of the data needed with respect to particular Soviet projects is derived from classified documents and publications which range from defector reports to the National Intelligence Survey. The latter gives geologic, meteorologic, and terrain information which can be of great value in determining the rate of progress to be expected in the work. Sometimes a refugee who had worked on the job can supply details about dimensions materials used, methods of placement or

erection, problems encountered, numbers and types of employees, and other things.

So much for the estimator's qualifications and his sources of information. His methodology can best be illustrated in a hypothetical case history.

Men at Work on Missile Complex

The following report of information might be received from a defector:

1. A military installation which employed very high security measures was under construction in an isolated, forested area northeast of Murashi, RSFSR, in July 1961. The personnel of the construction battalion were not told the purpose of the project but there was speculation that it was to be an inter-continental missile complex. Informant heard from other construction workers that many anti-aircraft rocket sites had also been built around this area though he did not see any of them.

2. This military installation, which was spread over a very large area, was geographically isolated from all activities and since the entire region was heavily forested a large amount of clearing was necessary. A rail spur had been built from the town of Murashi about 20 kilometers to the southwest. Near the end of the railroad spur a road had been built which ran parallel to the spur for a considerable distance and terminated in a large loop. All transport in the complex was by trucks.

3. There were four separate areas within the complex located about 8 km apart and connected to each other by roads. All four areas were similar in size and shape although each was in a different phase of construction. Each area covered about 35 hectares (approximately 90 acres) of land, and each contained two large flat graded areas approximately 350 meters apart, which were

parallel to each other. All of the graded areas were to be covered with a thick layer of reinforced concrete. At each of the locations a road connected the concreted platforms and an access road ran between and roughly parallel to them. Housing facilities had been constructed a short distance east of the rail spur terminus in an area central to all four sites.

4. Construction at the sites proceeded in stages or phases. One crew finished a phase at a site and moved on to another site to perform the same work. Meanwhile another crew moved into the first site to perform the next phase. By the end of July all the excavation work for the four sites had been virtually completed and it was rumored that these workers and their equipment would be moved to another complex of the same type to do the same kind of work.

5. With the exception of site A, informant did not know what degree platform concreting had progressed. He learned from fellow workers that at site A, which was in the most advanced stage of construction, the platforms had been concreted over, several buildings had been constructed, one of which was astride the access road, and a double barbed-wire fence had been erected. Only a few construction workers were left at site A and other personnel had already arrived to install equipment.

The problem is to determine how long it would take to build the four launch sites and how much it would cost. For purposes of simplification it has been assumed that a detailed estimate has already been made of the prototype launch area at the Soviet missile test range which seems to conform with the description of site A. Also it has been assumed that estimates of previously known deployed launch sites which likewise fit the description of site A have been

made. Since site A is in the most advanced stage of construction and shows the greatest detail of the four, the time sequence and breakdown of operations with respect to it will be studied first, and then the times and finally the costs can be extrapolated to cover the other three.

The Time Estimate

The first step is to divide the construction operation into its major components. For purposes of illustration a somewhat simplified listing distinguishes the building of access and intra-site roads, clearing and grubbing the land, excavation and drainage, building construction, launch pad construction, backfill and embankment, and finish grading. To these may be added, as making the site operational, a non-construction activity, installation and checkout of equipment. In each of these major components the estimator then sets about carrying out the work on paper, taking into account the information given in the Myrashi report, what may be known about the test range prototype and deployment sites of similar configuration, and all other available data. This is the critical phase of the estimating procedure because the validity of extrapolations to the other three sites and subsequent cost estimates depend on a correct reconstruction of the sequence of operations at Site A. It is here that the estimator must draw upon all of his past experience to make the practical judgments called for and adjust standard construction data to suit the particular circumstances.

Access roads are considered first because they are prerequisite to getting work started at the sites. Clearing starts at the same time, because the road right-of-way has to be cleared of trees and debris ahead of grading operations. The roads are rough-graded to carry equipment and supplies for starting work at the launch pad areas, and then the final grading, construction of culverts, and putting down of gravel sub-base is done. Paving is not usually begun until backfill and embankment around the site buildings is well under way and finish

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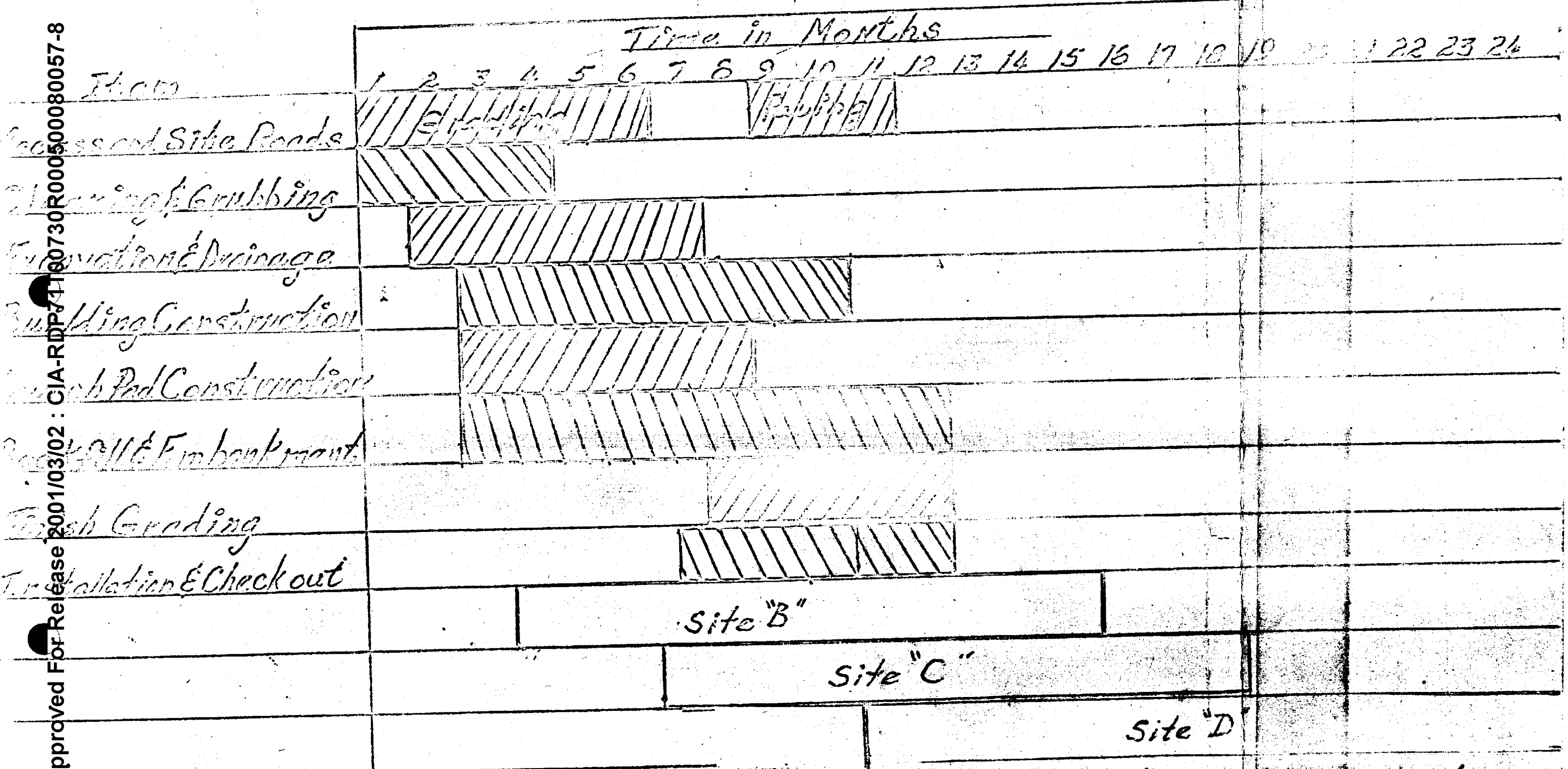

Figure 1 - Operational Breakdown showing time requirements for each activity for a Hypothetical Launch Areas

Note: Installation and checkout is not part of construction operations; it has been added here to make the rest of the data more meaningful.

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grading has started. The new pavement is thus less liable to damage from heavy loads of materials, heavy construction equipment, and cuts for utility lines.

Clearing and grubbing, starting at the beginning of the job, should be completed at the first site in four months. It can be done more rapidly than this or spread over the full period, using a smaller crew and less equipment, without noticeably affecting its total cost. It should be completed for the entire project by the end of the fourteenth month, when excavation at Site D is about half done.

Earth moving and drainage is a part of all the construction operations (not including installation and checkout). That for access roads, however, is included in the roads estimate. The time required to do the remaining excavation is estimated on the basis of the area to be worked and the amount of earth to be moved per hectare. Each site covers about 35 hectares. From a study of terrain maps of the locality and from knowledge of grading requirements on other sites of this type it can be estimated that the earth moving averages 3,500 cubic meters per hectare, for a total of nearly 125,000 cubic meters at each site. It appears to have proceeded on a normal schedule, having probably been started about one month after the access roads and clearing and grubbing were begun and completed for Site A at the end of the seventh month to fit in with the building construction schedule.

Building construction. A comparison shows that the buildings are of similar size and construction to those at the test range prototype, and the estimates made for these can therefore be used. They include two missile buildings, a bunker, and small ancillary buildings. The three types are figures separately in both time and cost estimates although built concurrently at each site. They

are begun as soon as the first excavation has been done, estimated at the end of the second month at Site A.

The launch pads are begun at the same time. The estimated time required to complete them is six months. The pads and ancillary buildings at the test range took considerably longer, but only because of the experimentation and changes characteristic of an R&D project.

Backfill and embankment begin as soon as the structures rise above finished grade elevations and the utility service lines are in place. It continues well beyond completion of the buildings and launch pads because many areas must be backfilled after the structures are completed and excess materials and debris removed.

Finish grading consists of replacing topsoil, fine-grading, and sodding or seeding. This final step in construction is not completed until after the paving is done and the site becomes operational.

The Cost Estimate

Much of the calculation necessary for determining cost has already been done in the time estimate. Quantities of work have been estimated and variations from the norm taken into account in order to fix the time required for each category of activity. All that remains is to arrive at adjustments for the standard costs per unit and make the arithmetical extensions.

From past estimates, which have proved to be quite close, 120,000 rubles per kilometer is assigned as the cost of grading and paving the access roads.

Clearing and grubbing has a wide range of costs, depending on methods and equipment used and the type and density of forest. In this area it has been found to run nearly 700 rubles per hectare, counting in the cost of clearing access roads.

Common (earth) excavation, usually a combination of truck-and-power-shovel method and tractor-scraper method, averages about 40 rubles per hundred cubic meters. Classified (rock) excavation, which usually costs about two and a half times as much, was probably unnecessary here. Trench and foundation excavation, which must be done by hand and is three to four times as expensive as machine excavation, is included in the unit cost of buildings.

For building construction it is impossible, unless a set of detailed plans is at hand, to figure every piece of material and every unit of labor required. But experience has shown it possible to estimate quite accurately by square meter of floor area for a particular type of structure; once the cost per square meter has been worked out it is used for all structures of the same type. Here the unit costs that have been carefully worked out and checked for the prototype structures at test range are used.

Launch pad unit costs are similarly taken from those at the test range. The normal learning-curve allowance for experience gained in building the prototype is not granted for this project because it is probably the first one carried out by its crew. The experience factor would be an important consideration, however, in the costing of a whole missile site construction program.

Backfill and compaction can vary in cost considerably according to what percentage can be done by machine and what has to be done by hand labor. By and large the unit cost runs about 25% greater than for excavation.

Finish grading, which can be very expensive if a great effort is made to "dress up" the project, is usually costed as a lump sum. Here, however, it can be figured on an area basis, the cost per hectare on sites of this type averaging 350 rubles to give about 50,000 rubles for the 140 hectares.

Item	Unit	Quantity	Unit Cost (Rubles)	Total Cost (Rubles)
Access Roads	Km	25	120,000	3,000,000
Clearing & Grubbing	Hectare	140	690	97,000
Excavation & Drainage	Cubic Meter	500,000	0.40	200,000
Building Construction				
Bunkers	Each	4	55,000	220,000
Missile Buildings	Each	8	40,000	320,000
Ancillary Buildings			Lump Sum	120,000
Launch Pads	Each	8	85,000	680,000
Backfill & Embankment	Cubic Meter	150,000	0.50	75,000
Finish Grading			Lump Sum	50,000
			Total Direct Cost	4,762,000
			Overhead (20%)	952,000
			Total Cost	5,714,000

Figure 2. Costs.

These unit costs, the result of much more detailed computation than can be indicated here, are then multiplied out and the results totaled as shown in Figure 2. To this total of direct costs it is necessary to add 20 percent for overhead -- on-site engineering, move-in and move-out expense, and administrative costs like salaries of supervising engineers and bookkeeping charges. Overhead costs thus amount to 17% of the grand total.

What is the range of error in this estimate? In the United States bids for construction jobs may range 20% above or below the engineer's estimate, that prepared by the designer and his staff prior to advertising for bids. A low figure reflects the contractor's conviction that he has found shortcuts for doing the job. (An interesting sidelight is the fact that about 2,700 U.S. contractors go bankrupt each year because they were low bidders and their shortcuts weren't shortcuts after all.) The intelligence estimator, however, is not trying to make a low bid, but the equivalent of an engineer's estimate of reasonable average

cost. In a country which lacks most of the elements of competitive bidding among construction organizations, a figure in the low-bid range would not normally represent actual costs. On the other hand, there is no reason to suppose with respect to an individual project that a figure in the high-bid range is the best approximation.

Nevertheless, Soviet construction organizations do vary considerably in experience and efficiency, and the effect of this variation on costs, although extremely difficult to quantify, should be kept in mind as one moves from static considerations to dynamic and from microeconomics to macroeconomics. If a program of missile site construction is judged to be of moderate size relative to the number and capabilities of experienced construction organizations and personnel that can be called upon, the cost per site, in general, is likely to tend toward the low-bid range. But if such a program seems massive enough to require, as it gathers steam, the employment of more and more construction organizations of less and less experience, the cost per site should settle in the high-bid range. In many estimates of the construction costs for new weapon systems we cannot expect to keep uncertainty within the plus-or-minus 20% of U.S. practice.